any thing that might contribute to a publick Bene-
fit, and to do fome juftice to Merit, could induce
me, I fhall only requeft that what I have here
offered may be conftrued by that Intention.

Philad. 28th of
June, 1734.

J. LOGAN.

Note, That the Radius of the Quadrant be-
ing divided into 20 equal Parts, the Center ×
(in *Fig.* 1.) of the Curvature of the Horizon-
Vane (A B) muft be 12 $\frac{8}{10}$ of thofe Parts from
the Center (C) of the Quadrant. The Breadth
(A B or *g h*) of that Vane fhould be $\frac{1}{10}$ of the
whole Radius, that is, $\frac{1}{20}$ on each Side of the
Center (C).

IV. *The Defcription and Ufe of an Inftrument
for taking the Latitude of a Place at any time
of the Day;* by *Mr.* Richard Graham,
F. R. S.

THE neceffity of finding the Latitude, a Ship
is in, is too well known to be infifted on : Fre-
quent opportunities of obferving the Latitude muft
consequently

confequently be of very great Advantage to Navigation. The Method ufually practifed, is by taking the Sun or Stars Meridian Altitude or Zenith Diftance : In this Cafe, if the Sun does not fhine but for fome fmall Time only, before Noon and after, though it be clear all the reft of the Day, it is of no ufe for this Purpofe. Mr. *Fatio, F.R.S.* (in the Year 1728) propofed a Method for finding the Latitude, from two or more Obfervations of the Sun (or Stars) at any Time, the Diftance of the faid Obfervations in Time, being given by a Watch ; but as his Method requires a vaft Number of Computations, and a great deal of Skill in Spherical Trigonometry, it has very feldom been made ufe of, and never but by good Mathematicians. The Inftrument here defcribed will anfwer the fame End, and has thefe Advantages; *viz.*

1*ft*, It may be very eafily underftood by Seamen.

2*dly*, It immediately fhews the Latitude of the Place.

3*dly*, It gives the Time of Day at Sea when no other Inftrument can.

4*thly*, It may be made as large, and confequently as accurate as is defired.

A Defcription of the Inftrument. See *Fig.* 2.

A B C reprefents part of the Hemifphere of a large Globe (half the Globe, and the Part below the Tropick are cut off, that it may take up the lefs room.) A C, half the Equator, divided into 12 Hours above, and 180 Degrees below, and fubdivided into Minutes,

as

as is likewife the lower Tropick DD. EE, a moveable graduated Meridian, turning on the Axis FF. G an Index to fix it (by the means of the Screw H) to any Hour. I*i* I, a circular Beam-compafs, the Center I*i* to be fixed on the Meridian to any De-gree and Minute of Declination, by the Method commonly called *Nonius's* Divifions : *k* the Point for drawing Arches, which is likewife fixed to any Degree and Minute by the fame Method. As the Meridian is at fome Diftance from the Globe, L is a piece of Brafs to fix on the Meridian, marked with *Nonius's* Divifions, with a Point reach-ing down to the Interfection of the Arches, by which means the Diftance of the faid Interfection from the Equator, or its Latitude is found. The Degrees and Minutes may likewife be fhewn by diagonal Lines.

The *Ufe* of the *Inftrument.*

I. PROPOSITION.

From two Obfervations of the Height of the Sun, the Diftance of the faid Obfervations in Time, being given by a Watch, as likewife the Declina-tion of the Sun ; to find the Latitude of the Place, and Hour of the Day.

I. *When the Ship is at Reft, that is, at Anchor, or in a Calm, fo as to have little or no progreffive Motion.*

Cafe I.

Cafe 1. Suppofe the Sun in the Equator, on the Day of Obfervation : Fix the Center of the Beam-compafs at o Degree (or at the Equator,) and move the Point *k* to the Zenith Diftance (the Complement of theAltitude, taken by the ufual Inftruments,) and from any Hour, as from C, defcribe an Arch of a Circle with the faid Point, as *b c* (*Ex.* 1.) Suppofe eight Hours after, by your Watch, you have another Obfervation ; move the Meridian eight Hours farther, to *d*, and fix it there ; and with the Zenith Diftance then obferved, defcribe another Arch as *e f*, the Point where it cuts the former is the Place of Obfervation, and its Diftance taken on the Meridian from the Equator fhews its Latitude ; and the Minutes reckoned on the Equator from the Meridian to C and *d* (the Times of Obfervation) fhew what thofe Hours were.

Cafe 2. When the Sun has Declination : Fix the Center of the Beam-compafs on the Meridian, to the proper Degree of Declination for the Day of Obfervation, and proceed as before.

Cafe, 3. If the Obfervations are at a greater Diftance than twelve Hours, but in the fame Day : Make ufe of the Complement to twenty-four Hours of the Diftance in Time, and take the Declination on the contrary, or lower fide of the Equator ; and inftead of the Zenith Diftances, take the Nadir Diftances or Altitudes increafed by ninety Degrees.

Thus

Thus you will find the Latitude, and Time of each Obfervation from Midnight. In this Cafe the Beam-compafs muft extend to more than 90 Degrees.

Cafe 4. If the Obfervations are more than a Day afunder ; as for Inftance a Day and two Hours (26 Hours :) Place the Centre of the Beam-compafs two Hours farther than it was the Day before ; but in different Declinations, according to the Table of Declination for the feveral Days.

Cafe 5. When the Obfervations are made by a Star : The Center of the Beam-compafs muft be fet to the Declination of the Star ; then proceed as before. To find the Hour in this Cafe, the right Afcenfion muft be likewife given.

Scholium. The fame Method may be ufeful at Land, when no Meridian Obfervation offers.

II. *The Ship in Motion.*

Cafe 1. Suppofe the Sun in the Equator : The Diftance between the two Obfervations eight Hours, as before, and the Arch *a a a* (*Ex.* 2.) defcrib'd by the Zenith Diftance of the firft Obfervation, from the Center C ; and the Angle *c a b,* 40 Degrees, is the Angle between the Ship's way, and the Azimuth of the Sun continued, (given by the Azimuth Compafs ;) and that during the eight Hours, the Ship has made one Degree, or 60 Minutes from *a* to *b,* or from the Sun ; then,

then, as Radius is to the Cofine of *c a b* 40 De-
grees, fo is *a b* 60 Minutes to *a c* 46 Minutes;
add 46 Minutes to the Zenith Diftance C *a* ; and
with *k*, the Point of the Beam-compafs fet at that
Diftance, defcribe the Arch *c b e*; then with the
Zenith Diftance of the laft Obfervation, whofe Cen-
ter is *d*, draw the Arch *f f*; the Point where it cuts
the Arch *c b e*, is the Place where the Ship was laft ;
and its Diftance taken on the Meridian from the
Equator fhews its Latitude ; the Minutes reckoned
on the Equator from the Meridian to *d* (the Time
of the laft Obfervation) fhew the Hour, or its Di-
ftance from 12 o' Clock.

Cafe 2. If the Ship had failed from *a* to β or to-
wards the Sun : The Cofine of the Angle β *a* γ, or
of the Angle between the Ship's Way and the Sun,
muft be fubftracted from the Zenith Diftance of the
firft Obfervation.

N. B. Only the two Arches *c b e, f f,* are to be
drawn on the Globe, the reft being added here, to
fhew the Reafon of the Conftruction.

Cafe 3. To find the Latitude of the firft Place :
From the Equator, with a pair of Compaffes, take
the Diftance failed 60 Minutes, and with one Foot
in the Interfection of the Arches *b e, f f,* the Place
found before, put the other in the Arch *a a a,* the
Zenith Diftance of the firft Obfervation, and in this
Inftance, on the left Hand of the Azimuth of the
Sun, this is the Place fought ; and its Diftance ta-
ken

ken on the Meridian from the Equator, fhews the Latitude ; and the Minutes reckoned on the Equator from the Meridian to C, the Time of the firft Obfervation, fhew the Hour.

The Interval in Time or Degree between the two Places, fhewn by the Index G, is the Difference of Longitude.

N. B. Thofe Obfervations are beft,whofe Arches crofs each other almoft at right Angles.

II. PROPOSITION.

The Zenith Diflances of two Stars, obferved at the fame Time, their Declination, and right Afcenfion being known ; to find the Latitude of the Place of Obfervation.

Fix the Center of the Beam-compafs to the Declination of either of the Stars, and with the Zenith Diftance of that Star defcribe an Arch ; move the Meridian as many Hours farther as is the Difference of right Afcenfion of the other Star ; and fix the Center of the Beam-compafs to the Declination of it; and with its Zenith Diftance crofs the firft Arch : The Interfection fhews the Latitude of the Place of Obfervation ; and alfo the Diftance of the right Afcenfion of the Zenith from that of either of the Stars, by which means the Hour may be known.

If a Celeftial Globe is made ufe of, then place the Center of the Beam-compafs over the feveral Stars.

The

The Latitude and Hour being given, the Varia-tion of the Compaſs is eaſily known.

N. B. In order to draw Arches on the Globe; rub ſome black Lead powdered on a piece of Pa-per; lay the Side which is black'd next the Globe, where you imagine the Interſection of the Arches will be : Then draw them on the clean Side with the Point of the Beam-compaſs, and they will appear on the Globe ; and if the Globe is well varniſhed, they may be rubbed out with Bread, or waſhed out with Water.

As Altitudes at Sea are now readily taken, with great Exactneſs, by the Quadrant invented by *John Hadley*, Eſq; V. P. R. S. and as the ſaid Altitudes are the Principles on which the Operations above deſcribed are founded ; the previous Uſe of that Qua-drant cannot but be of the utmoſt Importance to thoſe who ſhall have Occaſion for this Inſtrument.

The Deſcription and Uſe of this Inſtrument was laid before the *Royal Society Dec.* 9. 1731; but as I knew Mr. *Reid* was contriving one for the ſame Purpoſe, I delay'd making mine Publick. His Me-thod not yet appearing in Print, I have thought pro-per to communicate my own (eſpecially as 'tis now improv'd) conceiving it may be of ſome Advantage to Navigation.

P p p

An

Fig. 1.

Fig. 2.